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TITLE: Architecture for supporting service level agreements in an IP network

Brief Summary Text (7):

An approach is needed which will provide predictability on an IP backbone network, and do so for backbones with varying degrees of capability. If the network provider can predict the performance of the network, then he can implement service level agreements. A service level agreement is a formal contract entered into by a service provider and its customers. The service provider contracts to transport packets of electronic data between customer premise networks (branch offices, data centers, server farms, etc.) across the provider's backbone network with certain assurances on the quality of the transport. This is known as the Service Level Agreement (SLA). The SLA specifies customer expectations of performance in terms of parameters such as availability (bound on downtime), delay, loss, priority and bandwidth for specific traffic characteristics. An SLA includes acceptable levels of performance, which may be expressed in terms of response time, throughput, availability (such as 95% or 99% or 99.9%), and expected time to repair.

Brief Summary Text (8):

SLAs vary greatly from one network to the next, and from one application to another running on the same network. They are normally based on some level of expected activity. For example, if a large airline wants to ensure that the lines at the ticket counter do not get overly long due to poor response time at the ticketing terminals, some estimate must be made of expected workload, so that the network administrator can be prepared with the necessary resources to meet that workload and still remain compliant with the performance terms of the SLA.

Brief Summary Text (9):

Managing an SLA is an important task because of the revenue implications of failure to support mission-critical business applications. The problem is exacerbated due to diversity of the traffic and due to poor and varying degree of service differentiation mechanisms within the backbone networks. Commercially significant traffic must be prioritized above workloads which do not have a critical time dependency for the success of the business. Many of these workloads in an IP environment are far more volatile than those which have traditionally been encountered in the prior art, e.g. in native SNA environments. In order to meet customer requirements in this environment, a service provider must provide a large excess capacity at correspondingly high charges.

Brief Summary Text (10):

This situation dramatizes the need for effective tools which can monitor the performance of the IP network or system delivering a service over the IP network. While SLA management tools already exist in the native SNA VTAM environment, these tools do not generally exist for IP backbones. Also, there is a need for effective controls which allow the service provider of an IP network to manipulate the priority of the various workloads to be managed.

Brief Summary Text (13):

It is also an object of the invention to provide tools which can monitor the performance of an IP network as measured against multiple SLA agreements.

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Brief Summary Text (14):

It is a further object of the invention to provide effective controls which allow the service provider to manipulate the priority of the various workloads subject to SLA agreements.

Brief Summary Text (15):

Another object of the invention is to provide means for achieving network predictability which are adequate to implement a variety of SLA agreements over IP backbone networks halving a variety of capabilities.

Brief Summary Text (16):

It is yet another object of the invention to provide network traffic control tools enabling optimum allocation of network resources and minimizing the need to provide excess capacity in order to implement a variety of SLA agreements.

Brief Summary Text (17):

This invention discloses an architecture (SLA architecture) which organizes the key components, the specific function placements and communication mechanisms so as to enable efficient means of implementing new tools which greatly facilitate both development and enforcement of an SLA. Further, these advantages are even more significant when the backbone network such as current IP-based networks provide very little means for such service differentiation.

Detailed Description Text (5):

An Edge Device in the SLA architecture is a module that interfaces a customer premise network with the backbone network. (Currently, backbone networks vary widely in their resource management and service differentiation capabilities (e.g. an IP network with support for resource reservation and/or support for differential services using weighted fair queuing (WFQ) or class based queuing (CBQ), an ATM or Frame Relay network supporting switched virtual circuits with committed rates, etc). Such heterogeneity is expected to continue as vendors of networking equipment seek to differentiate their products. In such an environment, edge devices play the role of adapting the traffic entering the backbone network to the specific capabilities provided by the network in order to ensure that the SLA conditions are met efficiently.

Detailed Description Text (9):

1. Classification: Packets are categorized into separate streams based on a number of criteria that depend on the terms of SLA and the network capabilities. The Edge Device uses a set of classification rules to determine the appropriate service level category to which the packet is assigned. These rules may be configured in the Edge Device or obtained by querying a Directory Server. The details of the latter mode of operation will be discussed below in the context of the Directory Server operation. In a preferred implementation, only the egress edge device classification and class of service classification are necessary to provide service level agreements. For finer granularity control, the other classifications (path, channel, flow) can also be used. (a) Egress Edge Device Classification: The ingress Edge Device E1 that receives the packet from the customer premise network A1 obtains the identity of the remote or egress Edge Device E2 that the packet is expected to traverse before being delivered to the destination customer premise network A2, either directly from the packet or based on a lookup. (b) Path Classification: The ingress Edge Device E1 determines the path that is expected to be traversed across the backbone network by the packet. (c) Class of Service (classification: Packets with similar designated service categories are considered to belong to same stream. The class of service may be determined directly from information carried in the packet or may be based on other header fields carried in the packet, or based on a set of classification rules at the Edge Device. (d) Channel classification: A channel is defined as a stream of packets that have the same ingress and egress edge devices, that are expected to follow the same path

through the network and have the same Class of Service. The present invention also covers the case where all packets expected to traverse the same remote edge device are classified into the same channel, irrespective of the expected path within the network. (e) Flow classification: A flow is the basic packet stream unit over which a service level agreement may be specified. Typically, all packets in a flow belong to the same channel.

Detailed Description Text (14):

5. Policing: The SLA specifies the service levels that individual flows should receive as long as the traffic generated by these flows is within specified bounds. The policing functionality checks for violation of the traffic contract by flows and may penalize certain applications by degrading their service level temporarily (marking/dropping all such packets).

Detailed Description Text (15):

6. Pacing: During congestion states within the network, certain channels may be affected because they use congested portions of the network. As will be discussed later, the Control Server component of the SLA architecture is capable of detecting both the congestion state as well as affected flows. Under the directive of the control server, an Edge Device will regulate the rates of affected active channels to alleviate the impact of congestion.

Detailed Description Text (17):

8. Traffic prediction: This involves using the collected statistics to forecast near-term traffic (and the consequent resources requirement) of flows that will enter the backbone network from the Edge Device.

Detailed Description Text (18):

9. Performance monitoring: This includes estimating the bandwidth, delay and loss characteristics of selected flows. This function will be realized either using additional probe packets or using header fields if data packets are encapsulated before entering the backbone network. The frequency of probing is adjusted according to the SLA terms while maintaining a tight control over the overhead introduced by such additional traffic. The latter is achieved by ensuring that the overhead of probing does not exceed a certain percentage of the actual data traffic which is monitored by the statistics collection function. Performance monitoring can be done at the egress edge device only, or at a combination of the ingress and egress edge devices.

Detailed Description Text (19):

10. Policy control: This covers a variety of operations performed at the edge of the network, including access control, security, billing, etc. Network administrators may wish to allow or disallow the use of network resource based on the origin, destination or protocol used by the packet stream. In addition, policy control may involve authentication of applications and their desired service levels in an environment where end-hosts are capable of signaling their resource requirements/service priorities directly to the network. This function involves communication with a directory/policy server described below.

Detailed Description Text (21):

A control server in the SLA architecture is a module that acts as a repository of dynamic information (in accordance with the above referenced "quasi-static" approach involving adaptive time scales), e.g. resource utilization within a portion of the backbone network. Based on the knowledge of the topology, resource utilization and service level agreements with all customer premise networks, the control server computes the allocation of backbone network resources, and informs the edge devices of the pacing that must be done on various channels. To this end, the control server may perform some or all of the following functions:

CLAIMS:

18. A method for optimizing resource utilization among customers of an IP network, comprising the steps of: defining service level agreements for each said customer; establishing a control server as a dynamic repository of network information, said information including resource utilization, topology, and service level agreements; receiving said topology information at said control server, said topology information including edge devices through which said customers connect to the network; establishing a directory server as a quasi-static repository of network information, said information including policy rules for mapping traffic to service levels, and for mapping service levels to performance requirements; monitoring traffic on said network at each of a plurality of edge devices, said edge devices operating to classify said traffic; using said control server to compute the allocation of backbone network resources and issue pacing instructions to said edge devices; and propagating directory server information to network devices automatically and without reconfirming the network, said propagation being accomplished dynamically over long time scales, wherein said network is connectionless.